

Technological Development and Policies in the Scenario of Irrigated Agriculture in Brazilⁱ

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Abstract—The need for the conservation of natural resources is of paramount importance with regard to irrigated agriculture, since it is the main consumer and user of water resources in Brazil and in the world. Thus, technologies are being used to increase the efficiency of water use in irrigation and to conserve water resources. Patent data on technological developments of irrigation systems were collected from the National Institute of Industrial Property database, as well as legislation and public policies regarding irrigated agriculture in Brazil. A total of 732 patent registrations were registered in the period between 1974 and 2016. The number of patent registrations on the development of technological processes for irrigation has been increasing, as well as the implementation of policies aimed at irrigated agriculture.

Keywords—Irrigation. Efficiency in water use. INPI. Technology.

I. INTRODUCTION

For a long time, world agricultural production has been built under the guise of the productivist logic, established by the Green Revolution as a result of the population increase and increasing demand for food, aiming at maximizing productivity gains through technological advances; as well as the mechanization of the field and the use of chemical products, as well as the cultivation of monocultures, driving the development of commodity chains [5] [7] [14].

These factors are the consequences of the Industrial Revolution of the eighteenth and nineteenth centuries, which was dominated by the mechanization of mining and fossil fuel-producing factories, expanding the means of maritime and land transport, which resulted in

population growth and urbanization of the cities, thus increasing the demand for food, as opposed to the reduced number of rural workers moved by the rural exodus [10][18].

In spite of the productive advances for the agricultural sector by the Green Revolution, losses were generated to the environment, for example, deforestation of large areas for agricultural activities and formation of latifundios; planting of monocultures, which facilitated the dissemination of the application of chemical products for pest control and crop invaders; soil depletion caused by its intensive use concurrently with chemical fertilizer applications [2] [12].

At the same time, in order to conserve natural resources and promote sustainability with economic, social and environmental aspects, we find Conservation Agriculture (CA), aiming at high agricultural productivity [6], and that due to the increase in productivity in recent years, the use and exploitation of natural resources in order to supply the world food demand has become significant [8], the CA being based on the principles: (i) minimum soil rotation combined with no-tillage system; (ii) maintenance of soil cover by residues from other crops, acting as a fertilizer medium for successor crop, and (iii) adoption of crop rotation [17].

In this sense, it is deprived of the need to conserve available natural resources, highlighting the use of water resources, which has been associated with agriculture as the main consuming and user unit of these resources for purposes and irrigation using approximately 85% of the amount of water consumed globally [19].

It is aggravated by the fact that the small amount available for consumption is only 1.2%, which is fresh water contained in rivers, lakes and streams, since 97% of

all water on the planet is salted, and only 3 % is considered fresh water, readily available for human consumption. However, it is known that two-thirds of these fresh waters are present in the polar and glacial ice caps, and the other one third are groundwater [15].

In this sense, Brazil registered an average annual growth of 4% per year in the area irrigated since 1960, from 462 thousand hectares to 6.95 million hectares in 2015, which made the country one of the ten largest in an area equipped for irrigation, allocating about 70% of the total freshwater for irrigation [1] [11].

Thus, new technologies are being used in agriculture to increase the efficiency of water use in irrigation in line with the creation of legislation and public policies in irrigated agriculture, promoting productivity increase by conserving water resources [13].

The objective of this work is to verify the relations of public policies and legislation on technological development with a view to the efficient use of water.

II. MATERIALS AND METHOD

The methodology used for research is similar to that developed by [16], together with the database of the National Institute of Industrial Property [9] on patent registrations concerning the technological development of irrigation systems in the period between 1974 and 2016. Regression analysis was performed using Excel and Minitab® software, as well as Pearson's correlation coefficient, in order to determine the relationship between the variables studied, above the increase in the number of patents during the course years.

The search was carried out according to the International Patent Classification (IPC), respecting the hierarchical levels of the records in the INPI database. The patents referring to the technological development of irrigation systems classified in Section A (Human Needs), inserted in Subsection A01 (Agriculture) and allocated to class A01G (horticulture, cultivation of vegetables, flowers, rice, fruit, vines, hops or algae, silviculture, irrigation), these being divided into four subclasses: A01G 25 /, A01G 27 / A01G 29/ and A01G 31/, and distributed into 15 groups: A01G 25/00, A01G 25/02, A01G 25/06, A01G 25/09, A01G 25/14, A01G 25/16, A01G 27/00, A01G 27/02, A01G 27/04, A01G 27/06, A01G 29/00, A01G 31/00, A01G 31/02, A01G 31/04 and A01G 31/06.

The methodological focus was to quantify the number of patent registrations referring to the technological process of irrigation in Brazil.

On the other hand, the records related to the Public Policies were obtained by means of a search in the Federal Government Legislations database through keywords, such as: "Irrigation", "Irrigated Agriculture" and "Water Resources", in addition to consulting the

Atlas of Irrigation of the National Water Agency (ANA) of the Ministry of the Environment [1].

III. RESULTS AND DISCUSSION

A total of 733 patent registrations were recorded in the INPI database, between 1974 and 2016, over 15 classifications according to the International Patent Classification (IPC), as can be seen in Table 1.

Table 1. Classification of patents according to INPI (2018) and number of registrations in the period between 1974 and 2016.

Code	Description	Quantity
A01G 25/00	Irrigation of gardens, meadows, sports grounds or similar	87
A01G 25/02	Arrangements, for irrigation, under the soil of the piping medium. ex. for drip irrigation	138
A01G 25/06	Arrangements for irrigation by piping. Realized in not only	35
A01G 25/09	Splits for irrigation by means of escalators or similar	93
A01G 25/14	Handheld irrigation systems, p. ex. watering cans	14
A01G 25/16	Irrigation Control (Spray Control Devices)	100
A01G 27/00	Automatic irrigation devices, p. ex. for flower pots	84
A01G 27/02	You must have a water reservoir, one of the main risk factors for growth and the growth substrate	21
A01G 27/04	Using muslin or similar	4
A01G 27/06	with a water reservoir, a main part is being completely around or next to the growth substrate	4
A01G 29/00	Root feeding devices; Injection of fertilizers into the roots	20
A01G 31/00	Cultivation without use of soil, p. ex. hydroponics	68
A01G 31/02	Special apparatus for this purpose (apparatus for growing in receptacles or greenhouses in general)	51
A01G 31/04	Hydroponic culture in transporters	5
A01G 31/06	Hydroponic shelf culture or in stacked containers	9

The highest number of patent registrations in classification A01G 25/02, on provisions for irrigation under the ground by pipes with a total of 138 registers,

concentrating 18.8% of the records; with a percentage of 13.6%, are patents registered in the classification A01G 25/16 with 100 patents, which are technologies aimed at the control of irrigation. Following are the A01G 25/09 (93), A01G 25/00 (87) and A01G 27/00 (84) classifications, with the respective percentages of 12.7%, 11.9% and 11.5% of the concentration of patents.

On the other hand, the behavior on the evolution of the number of patent registrations regarding the technological development of irrigated agriculture is observed in Image 1

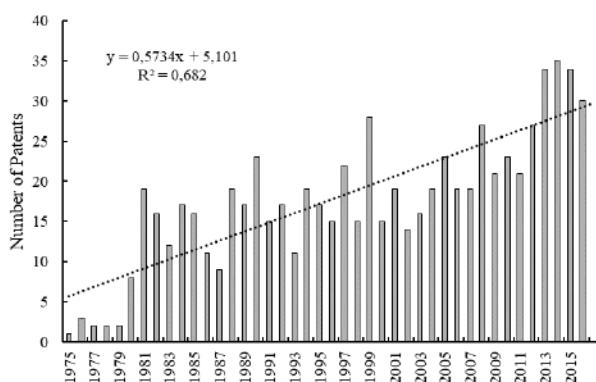


Fig.1. Total patents related to the irrigation system in Brazil.

In the analyzed period, the increase in patent registrations after 1979 was one of the possible causes, due to the approval of the first National Irrigation Policy, Federal Law 6,662 / 1979 [4], which aims to regulate the rational use of water resources and soil to promote the development of irrigated agriculture in the country [1].

After 1979 onwards, the number of patent registrations over the period is increasing, with the R^2 value found by the linear regression line equal to 0.682, which shows that 68.2% of the data can be explained by the equation of the line explicit in the model and regression

Likewise, the creation of public policies for irrigated agriculture in the period between 1975 and 2015 has also increased over the years, as can be seen in Image 2.

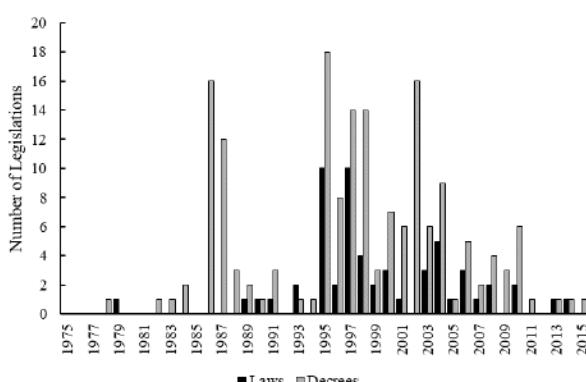


Fig.2. Number of Legislation (Decrees and Laws) created in the period between 1975 and 2015.

There is a total of 54.4% of laws in force between 1995 and 2000, increasing to 71.9% when analyzed until 2005, with 41 laws created by the Federal Congress. In turn, during the same period, the Presidential Decrees accounted for 34.3%.

The high number of laws in the period is emphasized in the historical landmarks of the public policies of agriculture irrigated by the Irrigation Atlas of the National Water Agency, described in Table 2.

Table 2. Historical and political moments of irrigated agriculture.

Ano	Historic moment
1979	First National Irrigation Policy (Federal Law 6,662 / 1979)
1988	Promulgated the Constitution of the Republic on the use of water resources
1997	Promulgation of the Water Law (Federal Law No. 9.433 / 1997) - National Water Resources Policy
2000	Creation of the National Water Agency (ANA) - Federal Law No. 9,984 / 2000
2001	Approval of CONAMA 284 of 08/30/01 - Environmental licensing on irrigation project
2008	Creation of the Permanent Forum for the Development of Agriculture Irrigated by Ordinance nº 1.869 / 2008
2013	Promulgated the new National Irrigation Policy (Federal Law No. 12.787 / 2013)

Source: Adapted from Atlas of Irrigation [1].

It stands out among the historical moment of irrigated agriculture in Brazil after 1979, five policies influencing the use of water resources in the mid-1990s and 2000, a period of more than 70% concentration of law-making by Congress Federal, along with the period of the conservationist movement, alluding to the productivist logic of agriculture established by the Green Revolution. Pearson's correlations between the variables, Year, Patents, Decrees and Laws, are shown below in Table 3.

Table 1. Pearson Correlation Matrix.

	Year	Patents	Decrees
Patents	0,83*	-	-
Decrees	-0,25**	-0,30*	-
Laws	0,18	0,11	0,10

Meaning top $< 0,05$ *, $p < 0,10$ **

There is a strong positive correlation between the Patents and Year variables, with a correlation value of 0.83 for a significance of 95%. On the other hand, the correlation is considered weak when the number of patents and number of presidential decrees are analyzed for significance of

95%, and the other correlations analyzed were considered negligible at statistical levels.

IV. CONCLUSIONS

There has been an increase in the number of patents related to the technological development of irrigation systems over the years, especially after the installation of the First National Irrigation Policy of 1979.

So that, the period with the greatest number of laws created between 1995 and 2005 is also described as the period of the main public policies dated as a historical landmark of irrigated agriculture in Brazil.

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